A SAWFLY LARVA FEEDING ON AN AQUATIC FERN (HYMENOPTERA: SYMPHYTA: PERGIDAE)

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Abstract

Larvae of *Warra froggatti* (Rohwer) (Pergidae: Euryinae) are described and recorded feeding externally on emergent fronds of a species of the aquatic fern, *Marsilea* (Marsileaceae). For the first time a morphological diagnosis for larvae of Euryinae is proposed. The biology of *W. froggatti* is compared with that of other Symphyta.

Introduction

Life histories are known for remarkably few Australian sawflies. Generally, biological observations have been made on only one or two species for each of the subfamilies Perginae, Euryinae, Pterygophorinae, Phylacteophaginae, Philomastiginae and Pteryperginae, whilst nothing is known of the Styracotechyinae and Pergulinae (Macdonald and Ohmart 1993). In this paper we present notes on the life history of the euryine sawfly *Warra froggatti* (Rohwer). Previously nothing was known of the biology of this species. Surprisingly for a pergid, its larvae feed on the emergent foliage of a tiny aquatic fern of the genus *Marsilea* (Fig. 1).

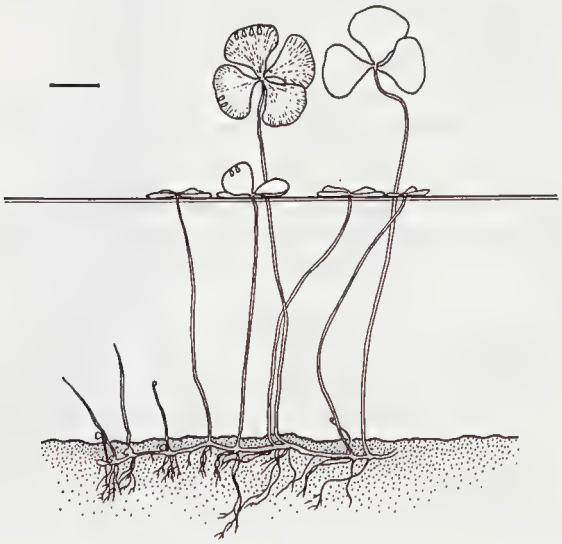


Fig. 1. Aquatic fern, *Marsilea* sp., showing *Warra froggatti* oviposition sites on frondlets. Scale line = 10 mm.

Warra froggatti was originally described in the genus *Clarissa* Kirby, from specimens collected by W. W. Froggatt in north-eastern New South Wales (Rohwer 1922). Subsequently, Benson (1934) proposed the genus *Warra* for *froggatti* and another species, *Clarissa anomocera* Rohwer, also from northern New South Wales. The literature concerning the genus has been catalogued by Smith (1978). The host plant of *W. froggatti* was mentioned by Naumann (1991) and Macdonald and Ohmart (1993), based on the observations detailed below.

In this paper we describe the external morphology of *W. froggatti* larvae, compare this with the morphology of the only other known euryine larva (that of *Polyclonus atratus* Kirby) and suggest a diagnosis for euryine larvae generally. Such a diagnosis has not previously been attempted by any author. The biology of *W. froggatti* is compared with that of *P. atratus* (reported by Moore 1957), several other euryine species (data from Naumann in press and unpublished) and Pergidae and Symphyta in general.

Methods and terminology

Adults and larvae were observed in the field and also in 28 ml, clear plastic vials. Representatives of all instars were preserved in 80% ethanol for morphological studies. The only preserved representative of the prepupal instar is a pharate individual; the prepupal mandibular dentition is clearly visible in this specimen but no other aspects of the prepupal morphology can be reported reliably. Adults and larvae are lodged in the Australian National Insect Collection, CSIRO, Canberra (ANIC). Terminology for larval morphology follows Smith and Middlekauff (1987).

External morphology of larvae of *Warra froggatti*

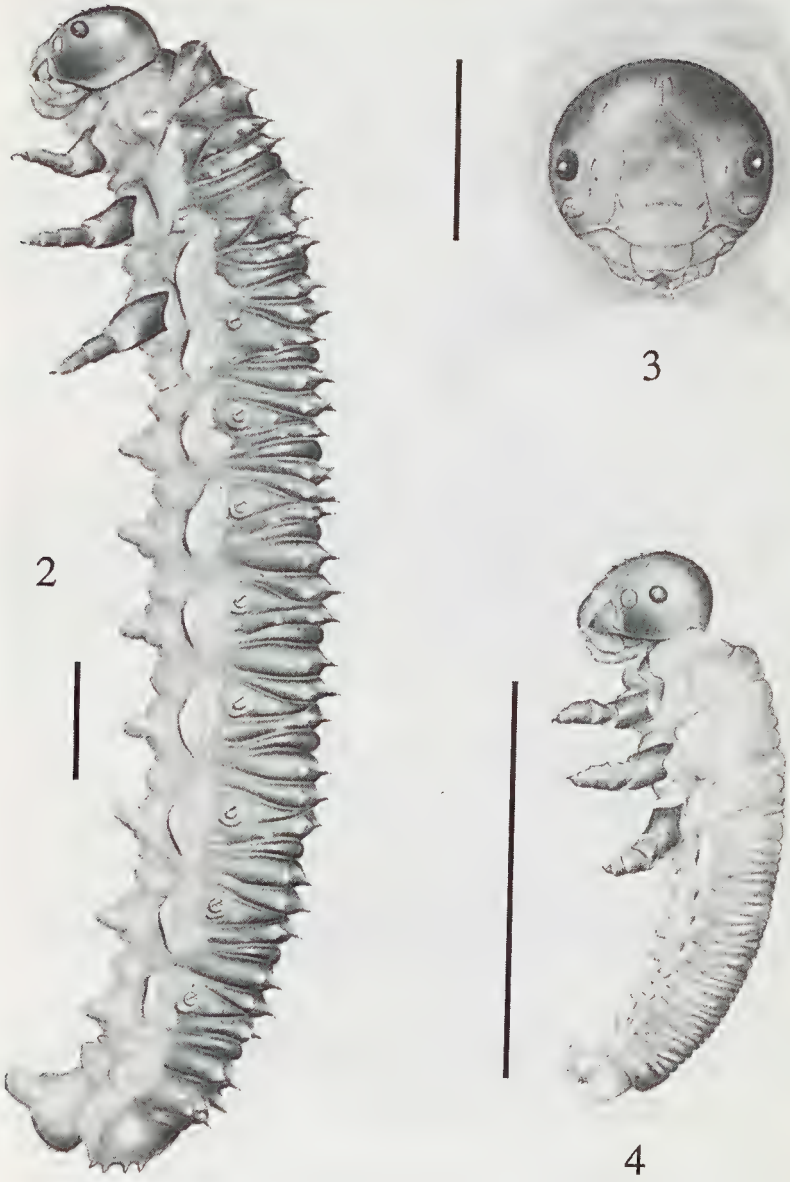
Description of third instar larva

Measurements. Total length (including head) 10-16 mm. Head width approximately 1.2 mm.

Colour. Live specimens: Head black. Thorax and abdomen lime-green. *Alcohol-preserved specimens*: Tips of mandible and tarsal claws dark brown. Head yellow-brown. Thorax and abdomen dorsally pale yellow, ventrally cream.

Microsculpture. Head smooth, thorax and abdomen very finely reticulate.

Head. Head sparsely setose (Figs 2-3), vertex bare, face with only a few scattered setae; length of setae less than maximum diameter of ocularium. Epicranial suture present. Stemma pigmented; diameter of ocularium greater than distance between ocularium and antennarium; ocularium slightly larger than antennarium. Antenna dome shaped, comprising 3-5 separate sclerites (posterior 2 sclerites discrete, anterior 3 very close to each other and appearing contiguous or fused); minimum (vertical) diameter of antennarium 1.2-1.3 times distance between antennarium and oral margin. Clypeus with transverse row of 2 setae. Labrum deeply bilobed, with transverse row of



Figs 2-4. Larvae of *Warra froggatti*: (2) third instar, lateral view; (3) head of third instar, frontal view; (4) first instar, lateral view. Scale lines = 1.0 mm.

4 or 5 setae. Mandibles asymmetrical; right mandible with 4 teeth, uppermost rounded and short, second acuminate and short, lower pair acuminate and long; left mandible with 5 teeth, uppermost rounded and short, second acuminate and short, third acuminate and long, fourth and fifth acuminate and progressively shorter. Palpal formula 5-3.

Thorax. Prothorax with single annulet, slightly overhanging posterior of head; annulet weakly bilobed, each lobe with 6-7 prominent tubercles; each tubercle with tiny, apical seta; seta shorter than tubercle. Prothoracic lateral process with 4 setose tubercles. Mesothorax with 4 annulets; first annulet with 1-2 subdorsal, setose tubercles; second annulet with 1-2 subdorsal and 2-3 dorsolateral-lateral tubercles; third annulet with 1 subdorsal and 3-4 dorsolateral-lateral tubercles; fourth annulet without tubercles. Mesothoracic lateral process with about 4 setose tubercles. Metathorax as for mesothorax. Supra-pedal processes absent. Legs each with coxa, trochanter, femur, tibia, tarsus and tarsal claw. Empodium shorter than claw.

Abdomen. Segments 1-9 each with 4 annulets; first and second annulets each with 1-2 subdorsal tubercles, 1 dorsolateral; third annulet with 1 subdorsal, 3-4 dorsolateral-laterals; fourth annulet without tubercles. Lateral processes of segments 2-9 each with about 4 tubercles. Suranal plate rectangular, lateral margin with 4-5 tubercles, posterior margin with 2-3. Segments 2-8 each with pair of widely separated prolegs, these sparsely setose, apically bare and membranous, appearing 2-segmented in some inflated specimens. Segment 10 with pair of medially contiguous prolegs, these much larger than those on preceding segments.

Description of second instar larva

As for third instar except total length approximately 9 mm, head width approximately 0.7 mm.

Description of first instar larva

As for third instar except total length approximately 1.4 mm, head width approximately 0.4 mm, head and thoracic legs much larger relative to rest of body; annulets less conspicuous; setigerous tubercles absent (Fig. 4).

Description of prepupa

Mandibles symmetrical with 4 teeth; uppermost rounded and short, second acuminate and short, third acuminate and long, lowermost acuminate and short.

Discussion

Few larvae of euryine sawflies are known. Moore (1957) described the immature stages of *Polyclonus atratus* Kirby and Naumann (in press) a larva presumed to be that of a species of *Clarissa*. Tillyard (1926) published a biological note on larvae of a species of *Diphamorphos* Rohwer but

unfortunately he did not describe the larvae and no specimens appear to have been preserved. The mature larvae of *P. atratus* and *W. froggatti* share the following features which also serve to distinguish them from the known larvae of other subfamilies of Pergidae:

> prothoracic annulet forming a 'hood' which slightly overhangs posterior of head; mesothorax, metathorax and most abdominal segments subdivided into 4 annulets; annulets with numerous setigerous tubercles; lateral processes present on most thoracic and abdominal segments; thoracic legs present, 5-segmented; abdominal segment 9 without elongate processes; suranal plate with peripheral setose tubercles, not forming elongate processes; abdominal segments 2-8 each with pair of prolegs; abdominal segment 10 with pair of prolegs or proleg-like structures.

The first author (IDN) has examined another six unassociated sawfly larvae (specimens in ANIC) which also exhibit all of these features. These unassociated larvae probably will prove to be the immatures of other species of euryine Pergidae. They differ amongst each other and from larvae attributed to *P. atratus*, *W. froggatti* and *Clarissa* in colour, microsculpture, development of the antenna, proximity of the ocularium and antennarium, mandibular shape and dentition, distribution of setigerous tubercles and shape of the suranal plate.

Biology

Notes on life cycle

The host plant for larvae of *W. froggatti* is a species of the aquatic and semi-aquatic fern *Marsilea* (Marsileaceae). The species cannot be determined conclusively but is probably *Marsilea drummondii* A. Braun. Commonly known as Nardoo, this fern grows in the shallows of fresh water pools and slow-flowing streams throughout mainland Australia. It favours areas subject to periodic inundation and is a common plant in parts of the inland and the north. It has a slender rhizome and fine roots which grow down into the mud (Fig. 1). Long pedicels arise from the rhizomes and grow upwards to the water surface. Fronds have 2 opposite pairs of frondlets which are radially arranged and generally float on the water surface. Commonly, when a frond floats on the water surface, one or more frondlets are raised slightly above the water. If the water surface becomes covered with frondlets, the fronds may stand erect with all frondlets well above the water (Leach and Osborne 1985, Williams 1980).

During this study *Marsilea* was examined at three localities near Townsville, Queensland (Alice River, Keebottom Creek, Bhole River) but *W. froggatti* was observed only at Alice River. Larvae and adults were recorded between April and May. Adults of *W. froggatti* have also been recorded from only two other localities: Ayr, approximately 110 km south east of Townsville (in

October) and the Warrah district, in north-eastern New South Wales (from October to December) (Rohwer 1922, Naumann unpublished).

Oviposition was observed in the laboratory and in the field. The typical oviposition site is between the upper and lower epidermis of the frondlet about 3 mm from the edge (Fig. 1). Usually 1-3 eggs are inserted in a frondlet, but up to 7 eggs have been recorded in a single batch. Oviposition takes place only on frondlets raised above the water surface. Eggs hatch after one to three days. Larvae feed during the day on the dorsal surface of frondlets.

Three instars were observed in the field, which is consistent with the two moults and two sets of exuviae observed in the laboratory. Larvae moult from the first to the second instar five days after hatching and from the second to the third instar two to three days later. The third instar feeds for four days before burrowing into moist soil at the edge of the water. The moult to the prepupa and pupation occurs in the soil. Adults emerged 7-9 days after the the final instar larvae entered the soil. Adults were not observed to feed in the laboratory.

Discussion

As far as is known, *W. froggatti* is unique among Pergidae and Australian sawflies in having a fern as the larval food plant.

There are about 180 species of Symphyta recorded from Australia and about 140 of these belong to the family Pergidae (Naumann 1991). Published records suggest that, at least in Australia, larvae of this family are predominantly associated with the foliage of myrtaceous plants (Macdonald and Ohmart 1993). Of the pergid subfamilies for which biological data are available, Perginae are well known on *Eucalyptus*, *Angophora*, *Syncarpia*, *Rhodamnia* and *Melaleuca*, Pterygophorinae feed on species of *Eucalyptus*, *Melaleuca*, *Callistemon* and *Leptospermum*, Phylacteophaginae feed on *Eucalyptus* and *Tristania* and Pteryperginae feed on *Elaeocarpus*. There are exceptions to this association with Myrtaceae: a pterygophorine which can be common on *Emex* and *Rumex* and species of Philomastiginae which feed on *Rubus*.

Pergidae occur only in Australasia and the New World. Little is known of the larval host plants of New World pergids but a broader range of families appears to be utilised. In the New World, pergid larvae have been recorded from Fagaceae, Juglandaceae, Vitaceae, Melastomataceae, Anacardiaceae and a number of cultivated plants such as guava (Myrtaceae) and potatoes (Solanaceae) (Smith 1990, 1993, 1995). Larvae of one Central American pergid belonging to the subfamily Perreyiinae have recently been discovered to be fungivorous (Smith 1995).

The subfamily Euryinae, to which *W. froggatti* belongs, also appears to depart from the association with living myrtaceous foliage. Larvae of the

euryine *Polyclonus atratus* feed on leaves of *Eucalyptus* and *Angophora* (Moore 1957) which is not exceptional; but it is unusual that these leaves, though still attached to branches, are dead or dying. Larvae of two other species of Euryinae are known to feed on dead leaves: Tillyard (1926) mentioned this habit for a species of *Diphamorphos* and a larva, presumed to be that of a species of *Clarissa* Kirby, has been observed feeding on dead leaves of *Ranunculus* (Ranunculaceae) in ground litter (Naumann in press).

Euryine larvae frequently are found on or close to the ground. *P. atratus* larvae shelter by day beneath leaves and plant litter under the branches of the host tree. *Diphamorphos* larvae have been found under bark (Tillyard 1926) and the presumed *Clarissa* larva lives on the ground among dead grass stems. Furthermore, a number of unidentified euryine larvae (see above) have been collected from leaf litter in eucalypt woodland and rainforest. These few records all suggest that euryine larvae are predominantly ground dwelling, feeding on dead plant material. The larva of *W. froggatti* is exceptional among euryines in feeding on live plant tissue; it feeds on a very low-growing plant but is not litter frequenting, except when seeking a pupation site.

The Euryinae are not the only group of Australian insects whose larvae appear to have abandoned life among the branches for one amongst the forest litter. This shift is paralleled in the Lepidoptera and in the Coleoptera. Lepidopterous larvae typically feed on green foliage and this is the case for many Oecophoridae. However, a large proportion of the Australian oecophorids feed as larvae only on dead leaves (Common 1990). Some feed on dead leaves still attached to trees, some apparently fall to the ground with dead leaves and branches, whilst some are found only in leaf litter. Many, if not most species of the largely Australian tortricid tribe Epitymbiini feed on dead myrtaceous leaves or leaf litter (M. Horak, pers. comm.). In the Coleoptera, the larvae of Chrysomelidae typically feed on living plant material. However, the larvae of Australian Cryptocephalini feed on dead leaves accumulating on the ground beneath eucalypts and acacias, which are the host plants for the adult beetles (Lawrence and Britton 1991).

The approximately 40 Australian Symphyta which do not belong to the Pergidae are distributed among the siricoid families (all of which feed within wood as phytophages or parasites), the Tenthredinidae (mostly introduced species and most associated with non-myrtaceous, woody hosts) and the Argidae (which feed variously on Portulacaceae, Cupressaceae and Proteacae). Thus larvae of no Australian Symphyta have previously been recorded from other than gymnosperms or angiosperms.

In contrast, in the Northern Hemisphere, ferns are important host plants for Symphyta (Benson 1950, Smith 1993). Ferns are the hosts for a few Tenthredininae and many Selandriinae (Tenthredinidae). Larvae of Blasticotomidae also feed on ferns. Most tenthredinid larvae feed externally

on the fronds. Larvae of *Rocalia* Takeuchi are unusual in that they feed on the spores of ferns. Larvae of *Heptamelus* Haliday (Tenthredinidae: Selandriinae) and all Blasticotomidae are borers and feed internally. The very earliest Symphyta, in Triassic and Jurassic times, probably fed on ferns and gymnosperms (Heitland and Pschorn-Walcher 1993), which would make the association of sawflies and ferns a very ancient one. In the absence of a phylogeny for the Pergidae we cannot infer whether the association between *W. froggatti* and *Marsilea* is primitive or derived within the family. However, the weight of host plant records for the Pergidae and the very specialised biology of *Marsilea* suggest that the association between *W. froggatti* and a fern is an apomorphy which has been derived within the family.

The observations above reveal several biological diffferences between *W. froggatti* and *P. atratus*, the only other euryine species for which the life cycle is known. *W. froggatti* females oviposit always into the host plant. Eggs of *P. atratus* are sometimes deposited on eucalypt leaves and sometimes on nearby grass. *W. froggatti* larvae feed by day and are not particularly gregarious, whereas larvae of *P. atratus* shelter together by day and feed at night or during dull days. The pupal cocoon of *P. atratus* is to be found either attached to vegetation or rocks, lying on the ground under plant debris, or in the upper 3 mm of soil. As far as is known *W. froggatti* pupates only in the soil.

The developmental period of *W. froggatti* (23 days from oviposition to adult emergence) is much less than that of *P. atratus* (10-26 weeks from egg to adult). There are six larval instars in *P atratus* and three in *W. froggatti.* Presumably this reflects the ephemeral nature of the food plant of *W. froggatti.* Water levels in the pools and streams in which *Marsilea* grow can fluctuate considerably: as water levels fall the fronds dry and die; as levels rise patches of *Marsilea* are inundated. Since *W. froggatti* larvae require fresh, green foliage, are slow moving and are not truly aquatic, any major fluctuations in water level would be fatal. *P. atratus* larvae, in contrast, are terrestrial and depend on dead leaves which are a much more enduring food source.

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